REPEATED SPRAYING TO CONTROL SOUTHWEST OREGON BRUSH SPECIES

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INTRODUCTION

Reclamation and reforestation of brush-covered forest lands is a major concern of foresters throughout the Pacific Northwest, where dense brushfields occupy large areas of potentially productive commercial forest land. Herbicides are known to kill many of the brush species effectively and economically. Unfortunately, however, most brushfields are composed of a mixture of evergreen and deciduous shrubs, including many that are resistant to herbicides. Repeated applications of herbicides will be needed to attain a degree of control sufficient to allow reforestation of most brush-covered sites.

To make reliable estimates of rehabilitation costs, foresters must know the number of resprays that will be needed to attain acceptable degrees of control in different brush associations. This paper reports the effect of repeated midsummer applications of herbicides as foliage sprays on some of the most abundant brush species in southwestern Oregon.

MATERIALS AND METHODS

During 1955, selected formulations of herbicides were tested as midsummer foliage sprays on 13 of the most common shrubby brush species on forest lands in southwestern Oregon. Each herbicidal treatment was applied as a foliage spray to drip point on 20 separate shrubs in a completely randomized design. Four species proved highly susceptible to herbicides and were readily killed with one spray application, but nine species proved only moderately susceptible or resistant to the initial spray treatment.[1/] Surviving shrubs of moderately susceptible and resistant species sprouted the following year from stems, roots, and/or burls; but many of the sprouts exhibited curling and necrosis indicating continued herbicidal activity.

In July 1957 and July 1959, resprouting shrubs in the moderately susceptible and resistant categories on these plots were again sprayed with the same formulations of herbicides with which they were treated in 1955. Only the most effective treatments from the 1955 tests were repeated in the respray treatments, which were designed to determine the cumulative degree of control attainable with repeated midsummer applications of herbicides as foliage sprays.

Herbicides used were low-volatile propylene glycol butyl ether esters of 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and dichlorprop or 2-(2,4-dichlorophenoxy) propionic acid. A fourth herbicide, 3-amino-1,2,4-triazole (amitrole), was a commercial preparation containing 50 percent active ingredient.[2/] Either water or oil-in-water emulsions containing 5 percent black diesel oil by volume were used as carriers in a 3-gallon knapsack sprayer with nozzle adjusted to deliver a fine spray.

The three treatments were applied at 2-year intervals near the end of the period of active growth for brush species in southwestern Oregon. This delay between treatments provided enough time for each spray to attain its maximum effect before re-treatment.

Stage of growth is also important in application of herbicides. The period of stem elongation is generally regarded as the optimum time for applying herbicides as foliage sprays. When the initial sprays were applied on mature shrubs in 1955, stems were growing in length on all species except serviceberry and canyon live oak. Respray treatments in 1957 and 1959, however, were applied just after stem elongation had ended. This timing may have been a bit late for maximum effect on the resprouting shrubs, but it allowed treatments to attain their maximum effect and minimized recovery between treatments.

1/ Gratkowski, H. Effects of herbicides on some important brush species in southwestern Oregon. U.S. Forest Serv., Pacific Northwest Forest & Range Exp. Sta. Res. Paper 31, 33 pp., illus. 1959.

2/ Fresh supplies of the three phenoxy herbicides were provided by the Dow Chemical Company when needed. Amitrol was furnished by Amchem Products, Inc. This cooperation is sincerely appreciated.

RESULTS AND DISCUSSION

Results of the spray treatments allow classification of the 13 shrubby brush species[3/] into five classes based on their susceptibility to repeated midsummer applications of herbicides as foliage sprays:

Class	Species
Highly susceptible (90 to 100 percent of the shrubs dead after one spraying)	Hairy manzanita Hoary manzanita Howell manzanita Deerbrush ceanothus
Moderately susceptible (90 to 100 percent of the shrubs dead after two sprayings)	Snowbrush ceanothus Varnishleaf ceanothus
Slightly resistant (90 to 100 percent of the shrubs dead after three sprayings)	Greenleaf manzanita Mountain whitehorn ceanothus
Moderately resistant (only one-third to two-thirds of the shrubs dead after three sprayings)	Golden chinkapin Golden evergreen-chinkapin Scrub tanoak Saskatoon serviceberry
Highly resistant (less than one-third of the shrubs dead after three sprayings)	Canyon live oak

Although the initial application of herbicides on mature shrubs in 1955 caused a nearly complete defoliation of all species, only one- to two-thirds of the crown was killed on shrubs in the moderately and highly resistant categories. This degree of control would probably serve to release young conifers from brush competition, but it would not be adequate for reclamation and reforestation of nonstocked brushfields. For release, the objective is not necessarily to kill the brush, but to increase the amount of light reaching young conifers and to decrease brush root competition for soil moisture and nutrients. One need only obtain a high percentage of defoliation, a fair amount of top-kill, and a minimum of resprouting. For brushfield reclamation, however, a high percentage of the shrubs must be killed and resprouting must be limited in amount and vigor, or the recovering shrubs will soon overtop coniferous seedlings, limit their survival, and the site will again revert to brush.

Results of these tests show, however, that repeated spraying can control even resistant species to a degree that seems adequate for reforestation. High percentages of kill can be attained on species in the three most susceptible categories. And, although an appreciable percentage of shrubs in the more resistant categories were still alive after three sprayings, almost all of the crowns were dead and only limited numbers of sprouts had been produced by the remaining live plants. Competitive potential of these shrubs appeared greatly reduced and site conditions much more favorable for survival of interplanted young coniferous trees.

Resprouting shrubs proved much easier to kill than full-crowned mature plants (table 1). For example, although the first application of herbicides on mature plants did not kill any shrubs of species in the moderately resistant category, the first respray on sprouts killed as many as 40 percent of the shrubs. When the surviving shrubs sprouted again, a second respray increased the percentage of shrubs killed to as much as 60 percent. Repeated sprays are effective, advisable, and worthwhile on sites where resistant brush species are abundant.

Effect on Individual Species

Four highly susceptible species, **hairy manzanita** (*Arctostaphylos columbiana* Piper), **hoary manzanita** (*A. canescens* Eastw.), **Howell manzanita** (*A. hispidula* Howell), and **deerbrush ceanothus** (*Ceanothus integerrimus* Hook & Arn.) were readily killed with one application of 2,4-D as a foliage spray. Effects of various formulations of herbicides applied as foliage sprays on these and other species are listed in table 1.

Snowbrush ceanothus (*Ceanothus velutinus* Dougl.) required two sprayings to kill a high percentage of the shrubs. In resprays, as in the initial treatments, 2,4,5-T proved more effective than 2,4-D on snowbrush; and a 4-aehg[4/] formulation of 2,4,5-T in an emulsion carrier was more effective than a 2-aehg formulation when applied as a midsummer foliage spray with

3/ Common and botanical names are those listed in "Standardized Plant Names," 2d ed., 1942, by Harlan P. Kelsey and William A. Dayton, except for golden chinkapin, which is in accordance with "Check List of Native and Naturalized Trees of the United States (including Alaska)," U.S. Dept. Agr. Handb. 41, 1953, by Elbert L. Little, Jr. Latin names and authorities are given in the section of this paper entitled "Effect on Individual Species."

4/ Pounds acid equivalent per 100 gallons of spray.

Table 1—*Cumulative percentage*[1] *of shrubs killed by repeated midsummer foliage sprays of herbicides on mature (1955) and resprouting (1957 and 1959) shrubby brush species*

Species and herbicide	Concentration	Carrier	1955	1957	1959
	Aehg[2]				
Hairy manzanita					
2,4-D	1	Water	100	(3)	(3)
2,4,5-T	1	Water	90	(3)	(3)
2,4,5-T	2	Water	100	(3)	(3)
Hoary manzanita					
2,4-D	1	Water	100	(3)	(3)
2,4,5-T	1	Water	85	(3)	(3)
2,4,5-T	2	Water	100	(3)	(3)
Howell manzanita					
2,4-D	2	Water	95	(3)	(3)
2,4-D	2	Emulsion	100	(3)	(3)
2,4,5-T	2	Water	85	(3)	(3)
Deerbrush ceanothus					
2,4-D	2	Water	90	(3)	(3)
2,4-D	2	Emulsion	80	(3)	(3)
2,4,5-T	2	Water	85	(3)	(3)
Snowbrush ceanothus					
2,4-D	2	Emulsion	20	65	(3)
2,4,5-T	2	Emulsion	30	80	(3)
2,4,5-T	4	Emulsion	40	95	(3)
2,4-DP + amitrole	2 2	Water	70	90	(3)
Varnishleaf ceanothus					
2,4-D	2	Emulsion	45	60	(3)
2,4,5-T	2	Emulsion	65	95	(3)
2,4,5-T	4	Emulsion	85	100	(3)
Mountain whitethorn ceanothus					
2,4-D	2	Water	5	20	55
2,4,5-T	2	Water	20	65	90
Greenleaf manzanita					
2,4-D	2	Water	15	45	90
2,4-D	2	Emulsion	20	30	80
Golden chinkapin					
2,4-D	2	Emulsion	0	15	25
2,4,5-T	2	Emulsion	0	25	55
Amitrole	4	Water	0	20	60
2,4-DP + amitrole	2 2	Water	10	30	50
Golden evergreenchinkapin					
2,4-D	2	Emulsion	0	20	30
2,4,5-T	2	Emulsion	0	15	55
Amitrole	4	Water	0	40	60
Scrub tanoak					
2,4-D	2	Emulsion	0	35	55
2,4,5-T	2	Emulsion	0	20	60
Serviceberry					
2,4-D	½	Water	0	40	50
2,4-D	2	Water	0	40	58
Canyon live oak					
2,4-D	2	Emulsion	0	0	5
2,4-D	4	Emulsion	0	0	5

1/ 1955 and 1957 sprays were rated just before the next respray was applied. The 1959 treatments were rated in autumn, 1960.

2/ Pounds acid equivalent per 100 gallons. For amitrole, read aihg (active ingredient per 100 gallons).

3/ Not resprayed.

ground spray equipment. The increased cost of chemicals for this treatment would be offset by a saving in time and labor costs required to attain a similar degree of control with a 2-aehg spray mixture. The less concentrated spray solution would necessitate a third spray application and take at least one more year to attain a similar degree of control. For economy in spraying individual shrubs, two applications of 3-aehg 2,4,5-T in an emulsion carrier are recommended for snowbrush ceanothus (table 2). This should produce an acceptable degree of control.

Varnishleaf ceanothus (*Ceanothus velutinus* var. *laevigatus* T. & G.) also was best controlled with 2,4,5-T. One treatment of mature shrubs with a 4-aehg concentration of 2,4,5-T killed 85 percent of the shrubs (table 1), and aerial parts of the remaining plants were dead to ground level. Therefore, one thorough spraying with 4-aehg 2,4,5-T in an emulsion carrier is suggested as the least expensive treatment for controlling varnishleaf ceanothus (table 2).

Mountain whitethorn ceanothus (*Ceanothus cordulatus* Kell.) was also more susceptible to 2,4,5-T than to 2,4-D, but this species required three midsummer applications of 2,4,5-T in water to produce a high percentage of kill. The initial application on mature plants in 1955 killed all aerial parts, but vigorous resprouting threatened to nullify this degree of control within a year or two. Of the treatments tested, a 2-aehg concentration of 2,4,5-T in water was most effective.

Almost complete control of **greenleaf manzanita** (*Arctostaphylos patula* Greene) was obtained with three applications of 2-aehg 2,4-D in water. Although the first spray treatment in 1955 killed almost all aerial portions of the mature plants, most shrubs resprouted vigorously from burls at the soil surface. The sprouts were small but vigorous, and large numbers of sprouts were produced by each burl. Therefore, although one application of 2-aehg 2,4-D in a water carrier can be expected to provide increased light for established young conifers

Table 2.—*Foliage spray formulations for midsummer application on individual shrubs*

Common name	Chemical	Concentration	Carrier [1/]	Comments [2/]
		Aehg		
Manzanita, hairy	2,4-D	2	Emulsion	Good control with one treatment
Manzanita, hoary	2,4-D	2	Water	Good control with one treatment
Manzanita, Howell	2,4-D	2	Emulsion	Good control with one treatment
Manzanita, greenleaf	2,4-D	2	Water	Good control after three treatments
Ceanothus, deerbrush	2,4-D	2	Water	Good control with one treatment
Ceanothus, snowbrush	2,4,5-T	3	Emulsion	Good control after two treatments
Ceanothus, varnishleaf	2,4,5-T	4	Emulsion	Good control with one treatment
Ceanothus, mountain whitethorn	2,4,5-T	2	Water	Good control after three treatments
Chinkapin, golden	2,4,5-T	2	Emulsion	Fair control after three treatments
Evergreenchinkapin, golden	2,4,5-T	2	Emulsion	Fair control after three treatments
Tanoak, scrub	2,4-D	2	Emulsion	Fair control after three treatments
Serviceberry, saskatoon	2,4-D	1	Water	Fair control after three treatments
Oak, canyon live	2,4-D	2	Emulsion	Poor control after three treatments; aerial parts almost all dead; limited sprouting

1/ Emulsions suggested are oil-in-water, containing 2 percent black diesel oil by volume.

2/ "Good control" indicates 80 percent or more of the shrubs dead and the remaining shrubs killed back.
"Fair control" indicates 50 to 80 percent dead and the remaining shrubs killed back.
"Poor control" indicates less than 50 percent of the shrubs dead after high-volume foliage spraying with ground spray equipment.

beneath a greenleaf manzanita canopy, competition for soil moisture and nutrients may not be appreciably reduced. In both conifer release and brushfield reclamation projects, respray treatments are deemed desirable on sites where greenleaf manzanita is abundant.

The respray tests show that 2,4,5-T is the most economical herbicide tested on **golden chinkapin** (*Castanopsis chrysophylla* (Dougl.) A. DC.) The initial application of 2-aehg 2,4,5-T on mature shrubs killed none of the plants,[5/] and the degree of control achieved was of questionable value even for releasing established young conifers from competition of chinkapin. After the third spraying, however, 55 percent of the shrubs were dead, aerial portions of the original crowns were dead to ground level on almost all remaining shrubs, and the living plants supported an average of only one 12-inch sprout per 6 square feet of original crown area. Of treatments tested, 2-aehg 2,4,5-T in an emulsion carrier is considered most useful for golden chinkapin.

Response of **golden evergreenchinkapin** (*Castanopsis chrysophylla* var. *minor* (Benth.) A. DC.) to herbicides is almost exactly like that of golden chinkapin. As for the latter, a 2-aehg concentration of 2,4,5-T in an emulsion carrier seems an effective and economical treatment for golden evergreenchinkapin. After three successive applications, 55 percent of the shrubs were dead, aerial portions of all original crowns were dead to ground level, and the shrubs supported an average of only one 7-inch sprout per 2 square feet of original crown area.

On **scrub tanoak** (*Lithocarpus densiflorus* var. *echinoides* (R. Br.) Abrams), 2,4-D was as effective as 2,4,5-T. Both herbicides killed similar numbers of shrubs in three treatments. Although sprouts were more numerous and slightly taller in shrubs sprayed with 2,4-D, the difference was not enough to be of practical significance. A 2-aehg concentration of 2,4-D in an emulsion carrier is suggested as most economical for foliage spraying of scrub tanoak.

On **saskatoon serviceberry** (*Amelanchier alnifolia* (Nutt.) Nutt.) a weak ½-aehg formulation of 2,4-D in water produced as good a degree of control as a stronger 2-aehg formulation. Only a few sprouts developed after these treatments (average one sprout per 5 to 8 square feet of original crown area); and in both treatments, the sprouts were similar in size (10 inches tall) and equal in vigor. A high percentage of kill was not achieved even with three successive sprayings of serviceberry. However, after the second application, all of the original crowns were dead and resprouting was so limited that the competitive potential of the shrubs was considered negligible. A 1-aehg formulation of 2,4-D in water is recommended for midsummer foliage application on serviceberry with ground spray equipment (table 2).

Midsummer foliage sprays on resprouting **canyon live oak** (*Quercus chrysolepis* Liebm.) were as ineffective as the initial sprays on mature shrubs in southwestern Oregon. After three successive treatments, only 5 percent of the shrubs were dead. Although all original crowns were killed, the remaining live plants had produced an average of two healthy 8-inch sprouts for each 3 square feet of original crown area. This degree of control would be sufficient for release of established conifers, but the developing sprouts might provide an undesirable amount of competition for new plantations of conifers in reclamation projects on sites where canyon live oak is abundant. Of treatments tested, 2-aehg 2,4-D in an emulsion carrier was as effective as any other on canyon oak.

Comparison With Aerial Spraying

Since aerial spraying is the usual method for application of herbicides on forest lands in the Pacific Northwest, foresters may wonder how these results of ground spray tests may be interpreted in terms of aerial spraying. Results of an aerial brush control project in the Siskiyou Mountains[6/] provide some leads for such interpretation.

Two brushfields were aerially sprayed with herbicides during July 1955, burned in September 1956, and resprayed in June 1958 and August 1959. Although the initial treatments on the two areas were different, both were resprayed each time with 3 pounds acid equivalent of low-volatile esters of 2,4-D per acre in oil-in-water emulsions containing 1.5 gallons of black diesel oil per acre. Total spray volume in each application was 8 gallons per acre. Estimates of degree of control obtained by aerial spraying (table 3) are based upon abundance of each species on sample plots in the sprayed and

5/ See footnote 1.

6/ Gratkowski, H. J., and Philbrick, J. R. Repeated aerial spraying and burning to control sclerophyllous brush. J. Forest. 63: 919-923, illus. 1965.

burned areas as compared to abundance on plots in unsprayed brush surrounding the areas.

Table 3.—*Estimated percentage of shrubs dead after three aerial applications of herbicides on brushfields in southwestern Oregon*

Species	Year sprayed		
	1955 [1/]	1958	1959
Mountain whitethorn ceanothus	0	28	44
Greenleaf manzanita	15	59	88
Scrub tanoak	0	—	42
Canyon live oak	0	21	30

[1/] Both brushfields were burned in 1956, one year after the initial application of herbicides on mature shrubs. Degree of control listed was determined before burning.

Kill obtained by repeated aerial spraying of mountain whitethorn ceanothus, greenleaf manzanita, and scrub tanoak was similar to that obtained with ground spray equipment. On canyon live oak, however, aerial spraying appears to have been more effective. This comparison indicates that aerial spraying can be expected to kill percentages of shrubs similar to those killed in the screening tests on individual shrubs described earlier.

CONCLUSION

Most brushfields on forest land in the Pacific Northwest include species that are somewhat resistant to herbicides. Where such species are abundant, repeated treatments will be needed to kill a high percentage of the shrubs. Results of both the screening tests and aerial spraying presented here indicate that respray treatments on such sites are effective, advisable, and worthwhile. Respray treatments in both cases were effective in killing resprouting shrubs, even in species that were somewhat resistant to foliage sprays on healthy, full-crowned, mature shrubs.

Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, the Western States, or the Nation. Project headquarters are at:

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Gratkowski, H.
1968. Repeated spraying to control southwest Oregon brush species. U.S. Forest Serv. Res. Pap. PNW-59, 6 pp. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Wild-land shrubs differ in susceptibility to herbicides, and foresters must know whether one or more sprayings will be needed to attain a desired degree of brush control. This paper shows degree of kill obtained with up to three midsummer spray treatments applied with knapsack sprayer on 13 southwest Oregon brush species. A comparison with similar aerial spray treatments indicates the results can be used to prejudge effectiveness of aerial spraying.

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